UNIVERSITY OF MESSINA

PhD in
"ENGINEERING"
XXXIX Cycle

Battery Management System

PhD Student: Eng. Marco Caselli

Tutor: Prof. Salvatore De Caro

Battery Management System

The BMS is an electronic device that monitors the operation of rechargeable batteries, preventing dangerous or suboptimal operating conditions. Its topic is to ensure safety, reliability, and efficiency, preventing the battery from operating outside its safe operating range.

The project consists in the study and development of a Smart Battery Management System for automotive applications, using the STMicroelectronics EVAL-L9963E-MCU evaluation board , based on the L9963E chip.

Functions

The main functions of an electric vehicle battery management system are:

- Battery protection to prevent operation outside its safe operating area.
- Battery monitoring by estimating the battery state of charge (SoC) and state of health (SoH) of the battery pack during charging and discharging.
- Battery optimization through cell balancing that improves battery life and capacity, thus optimizing driving range for hybrid (HEV), plug-in hybrid (PHEV), and fully electric (BEV) vehicles.

Smart BMS

The Smart BMS is an advanced version of the management system that integrates more sophisticated algorithms, distributed computing capabilities and connectivity cloud compared to a standard BMS

The main features of a Smart BMS are

- integration with IoT (Internet of Things) technologies and remote connectivity , to enable continuous monitoring and predictive diagnosis ;
- predictive and machine learning algorithms , which allow a more accurate estimate of the state of charge, health status and degradation conditions ,
- safety , achieved through robust communication protocols , multi-level protections and the ability to react in real time to critical conditions
- architectures , suitable for high voltage systems and large battery packs .

Hardware

To verify and experiment with the described functions , the **EVAL-L9963E-MCU evaluation board with L9963E chip** was used, **whose characteristics are:**

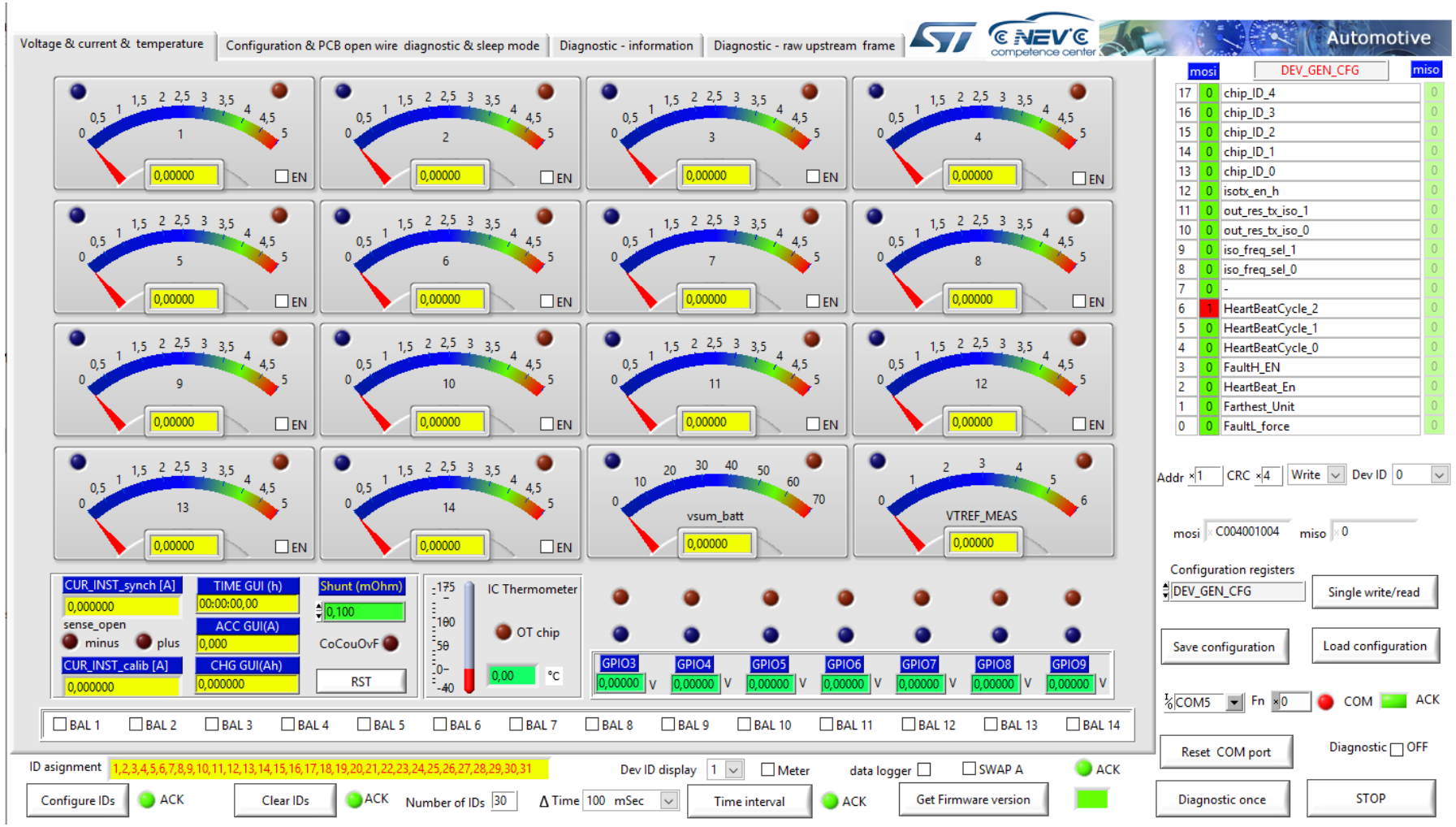
- Measures 4 to 14 cells in series, with 0µs desynchronization delay between samples
- Coulomb counter that supports battery pack overcurrent detection in both on and off state .
- Fully synchronized current and voltage samples.
- 16-bit voltage measurement.
- 2.66 Mbps isolated serial communication with regenerative buffering, supporting dual access ring.
- Transformer-based isolation.
- Up to 4 analog inputs for NTC sensing, plus PCB temperature sensing.
- SPC574S64E3 Embedded Microcontroller with 32-bit Power Architecture MCU for Automotive
- Integrated L9001 regulator as a power supply for microcontroller.
- Dedicated hot- plug circuit .

Software

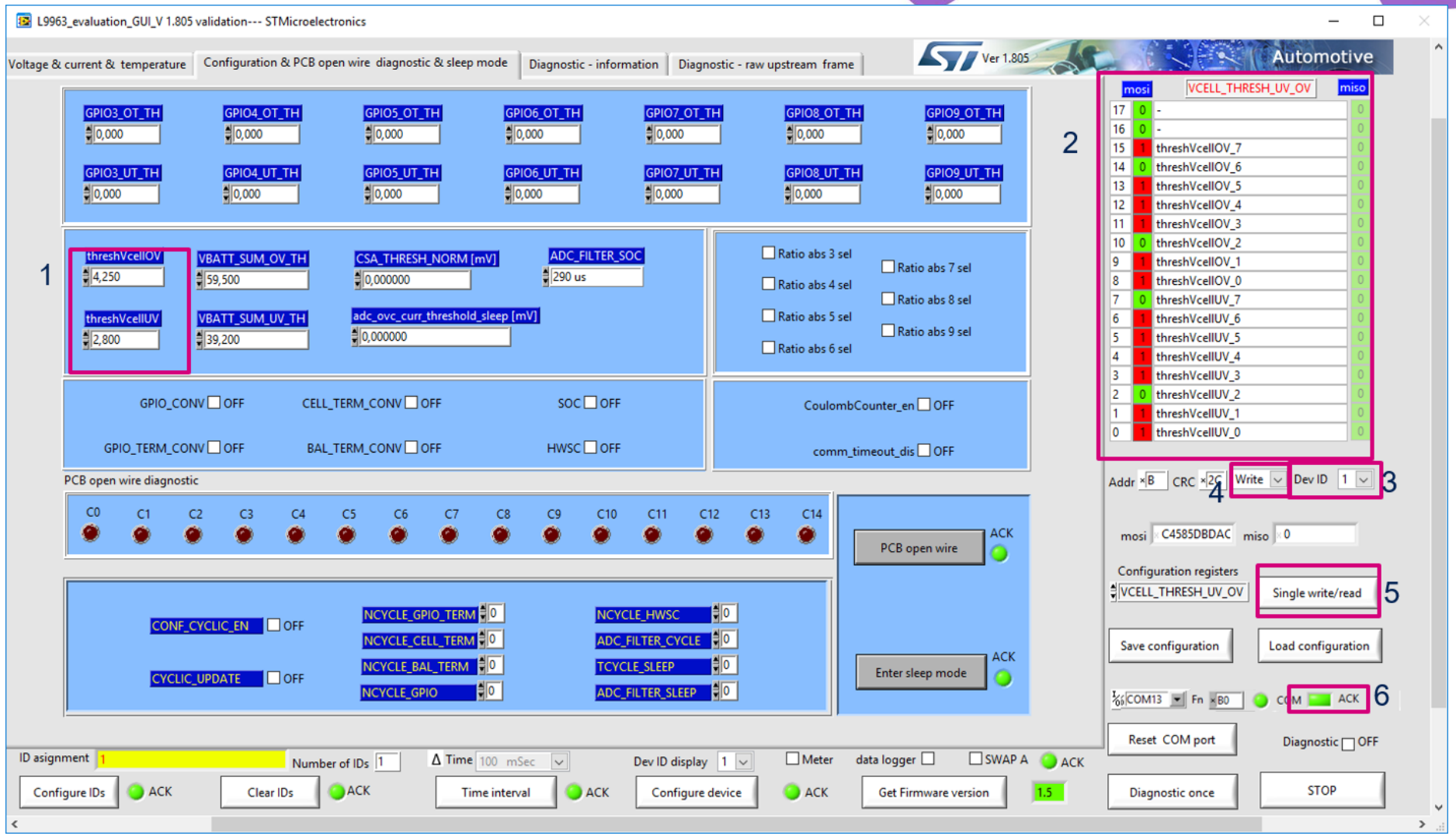
The STSW-L9963E software is a PC graphical interface developed to configure and manage the EVAL-L9963E-MCU board, used in Battery Management Systems (BMS) with the L9963E chip. It allows:

- to control all the functions of the chip,
- Monitor and diagnose your system, record and export data for offline analysis .

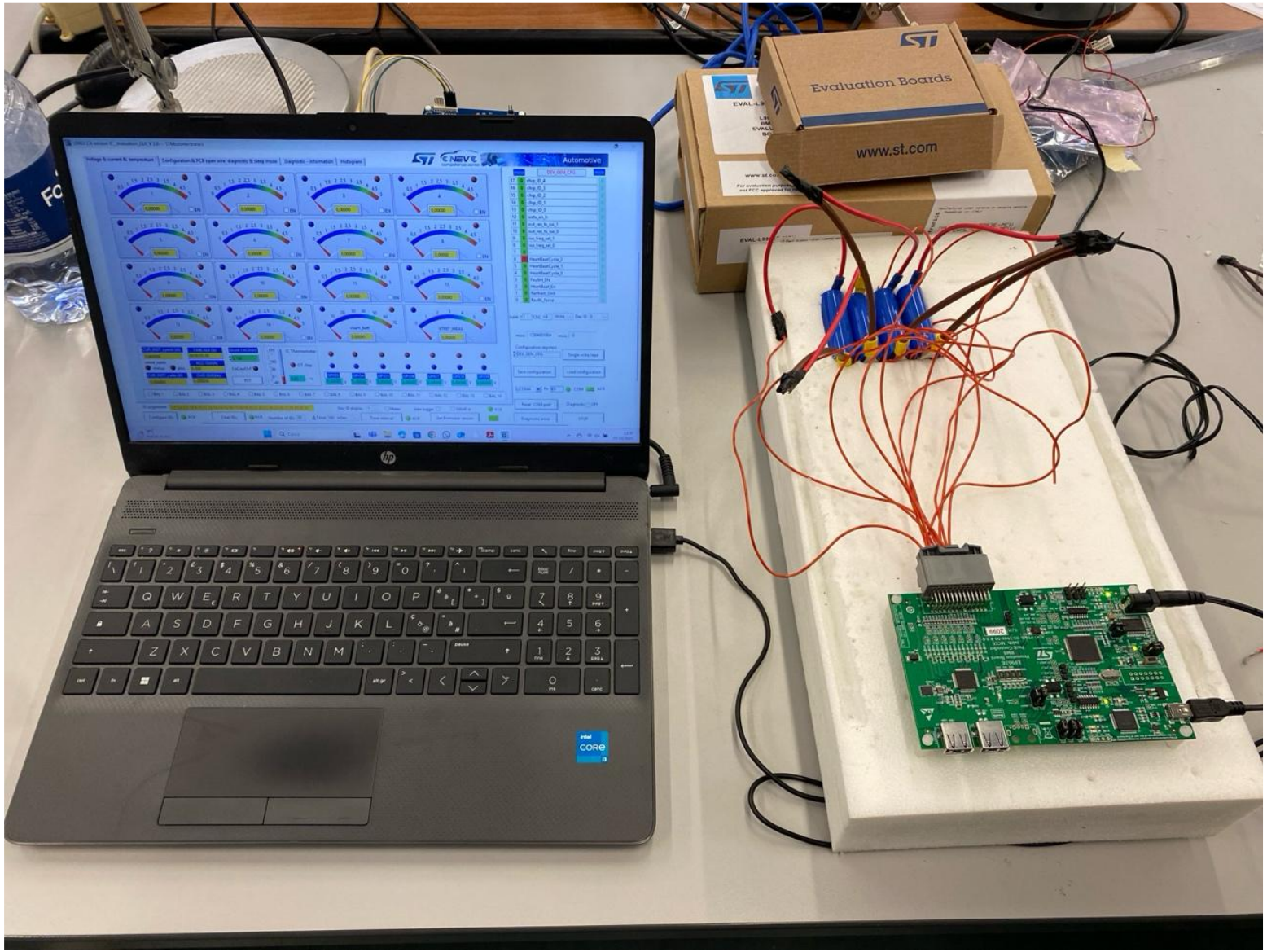
Graphical Interface



Configuring voltage thresholds



Test bench



Cells

The cells used are 18650 lithium-ion type

Measures

The measurements were recorded under controlled charging and discharging conditions, so as to observe the trend of the variables over time and verify the system's response to any imbalances between cells .

The data obtained form a basis for further analysis and confirm the consistency between the performance of the board and the typical functionality of a smart BMS .

Conclusions

The work carried out has allowed us to systematically study the structure, functions and potential of a Smart Battery Management System intended for automotive applications . After an analysis of the theoretical principles underlying the operation of battery management systems and the techniques for estimating fundamental parameters, the experimental activity has allowed us to concretely understand how hardware and software solutions can be integrated into an intelligent and reliable system.

Future developments

It will be possible to introduce more advanced algorithms for the estimation of the State of Charge and the State of Health of the cells, so as to obtain more precise measurements and more efficient energy management

The adoption of active balancing techniques, which allow the energy to be redistributed between the cells more effectively than passive methods , increasing the autonomy and life of the battery pack

Integrate the system with intelligent communication systems, such as vehicle-to-grid (V2G) networks , which allow energy and information to be exchanged with charging